

MEDICAL RESEARCH LABORATORY



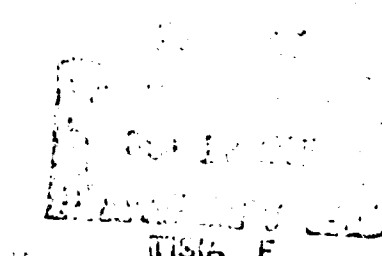
U. S. Naval Submarine Base
New London

THE DEVELOPMENT OF METHODS FOR THE SELECTION OF SOUND LISTENING PERSONNEL

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Medical Research Laboratory Report No. 1

C. W. Shilling
1 March 1942



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Background History Leading to the Undertaking of the Project.-Early in 1939 work was undertaken to determine the effect upon auditory acuity of some of the hazards encountered in the course of submarine duty. It seemed likely that there might be a detrimental effect upon hearing following exposure to conditions such as the continuous roar of diesel engines, the noise of gunfire, and the mechanical trauma of high pressure air, as in deep-sea diving and lung training. Detailed reports of the results of this work are being published in the U.S. Navy Medical Bulletin, the first section having appeared in the January 1942 number. In the course of this study it was noted that many of the men engaged as sound operators failed to measure up to the auditory requirements of the Manual of the Medical Department, Chapter 11, Article 1535 (d-3), although these same men apparently were capable operators of sound detection equipment. This led us to question the use of the audiogram as the sole means of selecting sound operators. An attempt was therefore made to discover tests which might better serve this purpose.

Early Search for Information.-Obviously, the first step was to ascertain what information was available bearing upon the problem at hand. To accomplish this numerous articles, reports, and books were read having to do with the physics and physiology of sound.

Visits were made to Harvard University Medical School, where conferences were held with Dr. Hallowell Davis and Dr. Stanley Smith Stevens; to Yale University for a conference with Dr. Walter Miles; to Columbia University and the Bell Telephone Laboratories in New York City; to the University of Toronto Medical School for a conference with Dr. C.H. Best and Dr. D. Y. Solandt, of the Department of Physiology; and to the University of Michigan to see Dr. Robert Gesel of the Department of Physiology.

Letters were written to and received from many eminent authorities in this field, among whom were: Dr. C. H. Best of the University of

Toronto, Dr. C. C. Bunch of Northwestern University, Dr. Hallowell Davis of Harvard University, Dr. Alexander Forbes of Harvard University, Dr. J. F. Fulton of Yale University, Dr. G. P. Harnwell of the University of Pennsylvania, Chairman of Section-4, National Defense Research Committee, Dr. Verne C. Knudson of the University of California, Los Angeles, Mr. W. H. Martin of the Bell Telephone Laboratories, Mr. W. A. Munson of the Bell Telephone Laboratories, Dr. Partridge of the University of Toronto, Dr. Stanley Smith Stevens of Harvard University, Mr. J. C. Steinberg of the Bell Telephone Laboratories, and Mr. George Wohlberg, Associate Engineer, U. S. Navy Yard, New York, and in the U. S. Navy: Rear Admiral Julius A. Furer, U.S.N., Rear Admiral Harold Wellington Smith, (MC) U.S.N., Captain E. W. Brown, (MC) U.S.N. (Ret.), Captain John R. Poppen (MC) U.S.N., Captain C. S. Stephenson (MC) U.S.N., Captain Lybrand Smith, U.S.N., Commander E. W. Silvester, U.S.N., and Lieutenant R. A. Krause, U.S.N.R.

The following groups or individuals have visited us in connection with the work which we are attempting to do: Representing the National Defense Research Committee--Dr. T. C. Fry of the Bell Telephone Laboratories, Dr. S. W. Fernberger of the University of Pennsylvania, Dr. A. Ford of Lehigh University, Dr. C. W. Bray of Princeton University, Dr. E. G. Wever of Princeton University, Dr. H. B. Hartig of the University of California, and Dr. M. S. Viteles of the University of Pennsylvania. Rear Admiral Julius A. Furer, U.S.N., Coordinator of Research and Development, and members of his staff: Commander E. W. Silvester, U.S.N., Commander C. R. Todd, U.S.N., Lieutenant R. A. Krause, U.S.N.R.; Rear Admiral Harold Wellington Smith (MC), U.S.N., of the Bureau of Medicine and Surgery; Dr. C. H. Best and Dr. D. Y. Solandt of the University of Toronto, and Dr. Miles of Yale University.

Locally, we have been in constant touch with the sound authorities aboard the U.S.S. Semmes,--Lieut. Comdr. William Pryor, U.S.N., and

Lieut. Comdr. Christian Engleman, U.S.N., with the director of the sound school at the Submarine Base, Lieut. Comdr. W. F. Irvin, U.S.N., and with many of the group of the Columbia Underwater Sound Laboratory at Fort Trumbull.

Equipment.-Work is being done in the basement of the Submarine Base Dispensary where we have at our disposal an office, two small sound rooms, and a large classroom. The entire basement is sandbagged, thus the noise level is considerably reduced. Testing equipment consists of: a 2-A and 6-B Western Electric Audiometer; a new Maico Audiometer; a General Electric sound level meter; a locally constructed pitch discriminating apparatus; a set-up for testing the ability to discern propeller noise against a background noise; both the "A" and "B" series of Seashore records; a Koerth pursuit meter; a two-hand pursuit meter; and numerous paper and pencil tests.

The Staff.-The staff consists of C. W. Shilling, Lieut. Comdr. (MC) U.S.N., William D. Neff, Ph.D., Psychologist-Statistician (who arrived February 10, 1942), Mrs. Jessie Williams Kohl, A. B., Secretary-Statistician (who arrived January 23, 1942), Chief Pharmacist's Mate Ira A. Everley, U.S.N., technician, and Chief Radioman Malcolm C. Leslie, U.S.N.F.R., Technician.

Funds.-Funds for the project have been furnished by the Bureau of Ships (a \$500. grant in December 1941), by Columbia University-Division of National Defense Research (which pays the salaries of Dr. Neff and Mrs. Kohl), and locally, by the U.S.S. Semmes and the U.S. Submarine Base, New London, Connecticut.

Subjects.-We are at present doing testing and selection work for three different groups:--

- (1) U.S. Navy enlisted men, candidates for training as submarine sound operators at the Submarine School, New London, Connecticut.

- (2) U.S.Navy enlisted men, candidates for training as sound operators on the U.S.S. Sylph under Lt.(jg) R.G.Snider,
- (3) U.S.Coast Guard enlisted men who are to be trained as sound operators under the direction of Lt (jg) R.G.Snider.

Tests Now Being Used.-(1) The Otis Self-Administering Test of Mental Ability is given to all subjects. We have found that for the majority of the men the Intermediate form, designed for Grades 4-9 is satisfactory. When necessary, we supplement with the Higher form, designed for High School and College use. At present, we recommend the elimination of only those subjects whose mental ability, so measured, indicates that they might have difficulty in acquiring the technical knowledge necessary to good sound operators.

(2) A brief questionnaire is filled out by each subject. This is not a complete personal inventory, but contains questions on amount of education, technical training, special skills (as radio and music), and attitude toward the job of sound operator. Since it is our firm conviction that the problem of motivation is extremely important, we are especially interested in obtaining some indication of each man's willingness to receive special training as a sound operator and his opinion as to the importance of this job.

(3) All subjects are given the Seashore Test of Musical Talent, Series "A". All six parts of the test (pitch, loudness, time, timbre, rhythm, and tonal memory) are used, special weight being given to the parts dealing with pitch, loudness and timbre discrimination. Since subjects may be given this test in groups of eight or ten, it is used in conjunction with the Otis test and the questionnaire as a rough means of eliminating those persons most unlikely to make good sound operators.

Over 200 subjects have now been tested on the Seashore Series "A". When classified according to standard methods, a fairly even distribution is found for all parts, except timbre where there is a predominance of cases in the excellent category, and tonal memory where there is a definite bunching

in the poor category. A complete detailed analysis of the Seashore test as a method of selection will be made the subject of a subsequent report.

Series "B" of the Seashore Test, a more difficult set of tests designed for examination of musical groups or selected individuals, was used at the start of the testing program and results were obtained for over 100 subjects. It was decided, however, that Series "A" was more suitable for the present testing program. If finer measures of pitch discrimination and the like are desired, they may be obtained with equipment which we have especially designed to more nearly resemble actual service conditions of sound detection. These tests are described in section (5) below.

(4) A complete audiogram is taken on all subjects selected for special training as sound operators. Since most of the men being examined are young and have not been subjected to conditions which might lead to deterioration of hearing, very few cases of severe hearing loss are found. When some deficiency is found, it is usually only partial and confined to frequencies of 4096 c.p.s. and above.

As might be expected, little relation is found between these partial hearing losses and ability of the subject in the other hearing tests, since the sound level in the other tests is considerably above the threshold and the frequencies involved are for the most part in the range from 200 to 2000 cycles. This is also true for actual sound detection work, that is, the sound levels used are far above the normal threshold and little use is made of the high frequency range.

(5) Special apparatus has been constructed for testing pitch discrimination under conditions similar to those of echo-ranging. Changes in frequency as low as one cycle per second may be produced. In actual practice, however, $2\frac{1}{2}$ cycles is the smallest change used. Various methods of arriving at individual proficiency were tried, the one finally selected is illustrated in the diagram below.

Cycles	A	B	C	D	Errors	High	Low	Total
1	H-20	L-10	H-5	H-2.5	2.5			
2	L-20	H-10	H-5	L-2.5	5			
3	H-20	L-10	L-5	H-2.5	10			
4	L-20	L-10	H-5	L-2.5	15			
5	L-15	H-10	L-5	L-2.5	20			
6	H-15	L-10	L-5	H-2.5	25			
7	H-15	H-10	H-5	H-2.5	30			
8	L-15	H-10	L-5	L-2.5	35			
					40			
					Total			
								Grand Total

Thirty-two pairs of tones are presented to the subject, the second of each pair being either higher or lower than the first. The subject indicates his judgment by marking an H or L in the appropriate blank. For example, the second tone of the first pair is 20 cycles higher than the first. The subject, if he discriminates correctly, should therefore place an H in the blank at A-1. The next pair of tones also differ by 20 cycles; this time the second, A-2, is 20 cycles lower than the first, and the subject should place an L in Column A, opposite #2. The letters in the foregoing diagram indicate the direction of change in pitch and the numbers the cycles change. The reference for each pair is 800 cycles. Determinations were made, experimentally, for a number of subjects at frequencies of 256, 1024, and 2048, but in actual practice 800 cycles is used as it is the frequency commonly used in echo-ranging.

The pitch discrimination test is given to every subject selected for training as a sound operator. We feel that this test is significantly related to the problem of sound selection, particularly where the individual is going to be required to use echo-ranging equipment. A more detailed discussion of the equipment and of the data obtained will be the subject of a report to be issued subsequently.

(6) Nearing completion but not yet in actual use is an improved and more accurately calibrated set-up designed to reproduce as nearly as possible conditions present in straight listening work. A sound similar to propeller boats is produced against a background of noise. Each can be varied independently. Data obtained on the first piece of such equipment convinced all of us that this phase of the investigation will yield important results.

(7) Analysis of the skills necessary for successful operation of sound-detection equipment, and discussion with persons who are instructing sound operators has led to the conclusion that tests of visual-meter and auditory-meter coordination may be valuable in our selection work. Therefore, we are attempting to devise such tests.

A Koerth pursuit apparatus, which gives a measure of simple hand-eye coordination, has been used for a number of subjects. We intend to replace it soon with an apparatus patterned after those being used in the selection of airplane pilots and rangefinders, which is an instrument involving eye-hand coordination of a more complex sort. This piece of equipment is now being constructed at the Submarine Base Machine Shop and should be in use in a few days.

(8) Since it is being used as part of the testing program at the West Coast Training School, the Bell Adjustment Inventory was tried on about 50 cases. Due to the fact that many of the items on the test are not appropriate for men in the Navy and also because of the type of questions (which the subjects considered "silly"), we found that the use of this test was not an aid in the maintenance of a serious attitude on the part of the persons being examined toward the whole testing program. In view of its undesirability from these standpoints and its questionable value as a means of selecting the emotionally unstable, we have discontinued the use of this test. We do feel, however, that the elimination of these persons who might "go to pieces" under stress is important and we are interested in finding more suitable means of discovering such cases.

Selection.-The Otis Test of Mental Ability, the Seashore Test of Musical Talent, and the questionnaire are given to all subjects. These are all group tests and are therefore suitable for the first rough screening of candidates. At present, purely arbitrary standards are set up for selection. When validation of the tests has been obtained these standards will undoubtedly be changed. A discussion of validation procedure is given below under the heading Plans for the Future. The present standards are roughly as follows:

(a) Elimination of all subjects having an I.Q. below 100. This standard is raised when possible, i.e., when only a few subjects are to be picked from a fairly large group.

(b) Elimination of all those men who, on the basis of their answers on the questionnaire, do not wish to attend sound school or do not think the job of sound operator is important. Selection of those who are willing or eager to undergo special training as sound operators and who think the job is important. Past technical training which might be of value and special skills are also given consideration.

(c) Selection of men who have highest rank on the Seashore Test and who have not been eliminated under "a" and "b". The tests of pitch, loudness, and timbre discrimination are here given greatest weight.

(d) In the future, the pursuit meter test will be given to all subjects and included as a means of selection.

After the first screening has been accomplished as described above, the remaining subjects are given the audiometer and pitch discrimination tests. Any with markedly abnormal audiograms are eliminated. From the remainder, those with the best scores on the pitch discrimination tests are selected.

The apparatus described under paragraph 8 will also be used in this final selection as soon as it is put into operation.

Plans for the Future.-The major concern at present is to establish the validity of the tests now being used. To successfully accomplish this will require: (1) Further selection of experimental data for all tests; (2) Statistical treatment of the data already accumulated; (3) The testing with our battery of selective tests of a group of sound operators of known excellence in practical service conditions; (4) The development with the aid of the two sound schools (Submarine Base and U.S.C. Sylph) of objective measures or grades indicating the proficiency in the school training program of those candidates whom we selected for sound school, thus providing us with a measure against which to correlate our selective tests; (5) The retesting of all sound school men after the completion of their course; (6) The securing of objectively evaluated reports from the fleet on the progress of the men selected for and graduated from our sound schools.

By such means we can eliminate those tests which have no predictive value and construct new and more efficient tests where needed. Changing service conditions and requirements may necessitate other changes in our testing program.

It must be remembered, however, that because of the exigencies of the times we cannot wait for the final accomplishment of the above goal, but must continue to select for Sound School an average of about 50 men per week by the admittedly incompletely developed methods already described.

Some of the tests are given to 8 men at a time, some to 2, and others individually, so that, for the actual testing alone, it takes an hour per man, which time would be doubled were grading, recording and correlating included. Thus, it may be seen that the routine work involved is considerable.